What Can Biologists Solve?

S. E. Luria

What is the relation of biology to social concerns, aside from work that is primarily medical? We hear from all sides that biology, and in fact all pure science, has become irrelevant, neglecting its obligation to pursue goals of physical betterment of man. We all know the fallacy of this viewpoint. We know that all science can find applications in appropriate times and circumstances. Even the most esoteric studies on bacterial gene action and on DNA and RNA synthesis have suddenly become central to the cancer problem. For example, viruses cause cancers, and scientists are searching within human cells for genetic material that may resemble cancer-producing viruses.

One could give many similar examples in defense of pure research; but that is not the point I wish to make. I do not disagree with the demand that scientists concern themselves with the consequences of their work. On the contrary, I firmly believe that such concern is very important. But I also believe that an intense guilt feeling about the "irrelevance" of one's work is counterproductive both to good research and to relevant research.

There is another, more insidious aspect to the relevance question: the attempt to saddle science with the burden of tasks that have little or nothing to do with science. Specifically, I believe that today biologists are being pressed to take on, as their professional responsibility, the study of certain problems that are not, or at least not primarily, biological problems, but social problems. In my opinion this is not an accident: it is part of a technocratic tendency to see only the technical aspects of human problems—and, when these aspects do not exist, to invent them. Let me give you several examples of what I have in mind.

The first example concerns the so-called ecological crisis and the pollution of the environment. Well-known biologists as well as other earnest persons have joined in alerting the public to the worrisome state of our air, our waters, our soil. That is fine. But, in the face of the crisis, if a crisis does in fact exist, biologists and other scientists have now been called upon not only to help correct the immediate consequences of pollution and to advise on future policies, but to assume responsibility for new approaches to the management of our environment. Universities have established courses and programs in ecological science, environmental biology, and other new specialties—often without any specialists to man these programs.

I do not question that applied biology can help to correct some ecological troubles. But it seems clear to me that the central problems are not biological. Neither are they scientific or even technological. They are social, and their solution depends on radical changes in social priorities and on improved machinery to enforce those priorities.

If the ecological crisis exists it is a social and political crisis, brought about in part by population increase and urbanization, and in great part, at least in this country, by the unfettered and selfish exploitation of natural resources by industry—aided and abetted by the government. To call on scientists to solve the ecological crisis is but an exercise in buck-passing, as it would be for the board of directors of the Pennsylvania Railroad to ask their train conductors to rescue the railroad from bankruptcy.

If scientists are lured into claiming that they have the know-how to solve what are really social crises, they will share the responsibility for the fact that these crises remain unsolved. They actually aid and abet those who are responsible for generating and maintaining the crises. Physicians are well aware of comparable attempts to use medicine as a cover, in order *not* to attack the real roots of a variety of social problems, from drug addiction to malnutrition.

My second example is a somewhat subtler one. It has to do with violence. We are told by ethologists and by politicians that crime and violence, from murder in the city streets to the automated battlefield, are the expression of aggressions that man has inherited from his brute ancestors, only made worse by man's intellectual capacities. They are claimed to be the behavior of the "naked ape." According to ethologists, including the most famous ones, aggression is part of the biological nature of man as of cyclid fish; violence is the natural function of the limbic system of our brain; crime and drug addiction are manifestations of certain genes or groups of genes; kind-hearted social measures have "failed" to correct these evils; and it is now time for biologists to face their responsibility, their manifest destiny to save and redirect the future of the human race by improving experimentally the heredity of mankind—presumably by selecting the meek or eliminating the violent.

Such calls for biologists to take over from soft-headed sociologists and criminologists the burden of research responsibility come not only from some ethologists (and, of course, from right-wing politicians) but also from some respected experimental scientists who in their own work would never be caught misreasoning as they do in social matters. One very distinguished scientist, in advocating a biological approach, argues that criminality can be an expression of the beast in man. Then he bemoans the frightful increases in crime in the last decades, as if here were not evidence for the social nature of the crime problem!

It is easy to see that such biologizing of crime and aggression serves to make people close their eyes to what crime really is: a social illness, fed by poverty and by profit. On the one hand, the major increases in crime have coincided with the industrialization of crime—in the prohibition period, in the Mafia, in the drug-importing and marketing industry—in parallel with the industrialization of most other activities in our society. On the other hand, crime is a product of poverty and exploitation, as it has always been. It is not the expression of a few genes or chromosomes. We biologists and medical scientists should be alert not to let our sciences be dragged into these kinds of sterile pursuits.

One more example: the current but not novel controversy about race and IQ. Intelligence tests, standardized to predict success in school under present curricula, have shown an average 15-point difference between white and black Americans. A few psychologists and educationists, on the basis of shaky and probably meaningless evidence, have asserted that most of the difference is attributable to heredity. Too many people have already pointed out the pitfalls and fallacies in the methods used in these studies for me to do the same here. One important argument, however, is worth mentioning: according to an elegant analysis by Bowles and Gintis, the IQ, no matter how predictive of success in school, turns out to be almost irrelevant to economic success in life. The son of an industrialist with an IQ of 90 has an enormously better chance to succeed than a black boy with 120.

There is an even more cogent argument. Even if IQ were inheritable and its differences between races statistically significant, there is nothing sensible one can do about it, except possibly abolish the IQ tests (which may not be a bad idea) or improve school curricula (if one knew how)—unless, of course, what the IQ enthusiasts want is to segregate the races: in schools, perhaps, or in concentration camps.

Whenever self-appointed experts state that the problem of impoverishment of IQ is a major problem facing our nation, I see racist eugenics raising once again its ugly head. Behind the urgent scientific necessity to know the truth about those miserable 15 IQ points, on which the whole future of the schools, the nation, and the species is claimed to depend, there is a movement to drop the current efforts toward integrated schools and equalized opportunities for black and white children. If biologists let themselves be enticed into the quicksands of the genetics of IQ, they will end up as the stooges of the forces of racial bigotry. How to get the most out of each person according to his or her ability is not a biological problem. It is a problem of social organization and social responsibility—as are the problems of pollution and crime.

Thus the three problems I have mentioned, although claimed to present socially relevant tasks for life scientists, turn out to be socio-political traps beyond the scope of science.

As biologists we must resist the lure of research on nonbiological social problems. For better or for worse, we must continue to develop our science along the lines we are currently pursuing, with a success comparable only to the successes of physics in the first quarter of this century. Just now the most esoteric aspects of these advances, such as synthesis of RNA and DNA or membrane chemistry, have begun to find direct applications to cancer and other diseases.

But as we pursue our own exciting business as biologists, it will not hurt us to have some grander vision. It is good even at my age to dream about greener pastures, if not for oneself at least for one's science as a collective enterprise.

I was thinking along these lines this past summer as I walked through the British Museum, going from the Elgin Marbles to my favorite set of sculptures, the Assyrian bas-reliefs of Assurbanipal. A few yards away are the beautiful hand-painted scrolls of all religions of man. Next to them, manuscript letters of the greatest minds of our culture—Shakespeare, Descartes, Newton, Voltaire, Shelley, and many others. Most touching of all, the diary written by Captain Scott, freezing to death at the South Pole in pursuit of knowledge and duty. I found myself thinking: what kind of instrument is the human mind, which plans and dares and fails and hopes? Will biology ever be able to unravel this greatest of wonders? Will man be able to understand in molecular terms how he himself thinks and feels and learns, remembers and forgets?

Such a biology of the human spirit, if I may call it that, must start, of course, from the biology of the mammalian brain: how it is constructed, how its various parts are connected, how signals originate and are processed. But ultimately it must be more than that: it must explain not only the mechanical aspects of neurophysiology but also the remarkable superstructure that we call the mind. It must interpret in biological terms—not in terms of biological determinism—the choices that the human mind makes among different possibilities. It must explain the apparent freedom of these choices, that is, the freedom of the will. And it must come to grips with the most intriguing feature—the creativity of the human spirit. Some may believe that a biology of the mind is impossible, either on theological or on philosophical grounds. I take here a different view, that a biology of the mind is feasible and is one of the great goals of science, possibly the greatest.

The mind, whatever it may be, operates within the network of neural connections in the brain. Applied mathematics and computer science can contribute analogs of the brain network that help clarify what any model of the human brain must be able to account for. But the brain is not a computer. On the one hand, it grows: it is made anew in each individual, starting from the instructions of the genes, which provide a specific chemical program for the brain as they do for any other organ. On the other hand, the brain's creativity is beyond the combinational possibilities of any computer, if nothing else because of the thousand billions of nerve cells in a human brain.

The brain, of course, is an old invention. The vertebrate brain itself predated man by a half billion years. The synapses or connections between nerve cells that underlie the brain network are roughly similar in invertebrates as in man. The directing processes that during the development of the organism and specifically of the brain generate that network are an immediate challenge: one needs to understand the "individuality" of nerve cells that causes a given nerve fiber from the eye, for example, to make precise connection with a given cell or group of cells in the lower brain, which in turn send their fibers precisely to certain columns of cells in the brain cortex.

Dr. Stephen Roth of Johns Hopkins University has reported that in the early chick embryo the nerve cells isolated from any given part of the retina have already a tendency to stick preferentially to fragments of those parts of the chick brain to which they would later send their fibers. This is true even before the retinal cells have started to make their fibers. It seems, therefore, that the program for specific recognition is expressed independently in the retina and in the brain on the surface of the cells that have to become connected. Just as a manufacturer color codes the terminals of electric wires so that the electrician knows how to assemble an appliance, so does the genetic program mark the surface of nerve cells with specific chemical markings.

Nothing that we now know about the chemistry of cell surfaces can explain the precise specificity required to account for such precise recognition between one cell and another. Yet we are confident that phenomena of this kind will yield to ever more refined biochemical and physiochemical analyses. The brain network is hundreds of million years old and its basic features should yield to animal experimentation. But matters change when we come face to face with something uniquely human.

Human language has evolved in the last million years or so, that is, in a relatively tiny time span on the scale of evolution. It was a new invention, which not only changed the destiny of the line of descent in which it appeared but affected all living species and the fate of the earth itself. Human language permitted communication between individuals and between distant generations of men. By making conceptual thinking possible it created culture and thereby the intellectual enterprise. In turn, culture probably relegated whatever instinctual drives man had inherited from his ancestors to a secondary role—ethologists notwithstanding.

Language, of course, was not a miracle: it was a biological invention, like the wing of the bird and the fin of the fish. The study of human language, of its underlying neural mechanisms, of how these operate in the uses of language for logical and creative thinking, seems to me to be the supreme and yet attainable goal for a human biology—I would almost say a "humanistic" biology.

Is there a justification, one may ask, for attempting to biologize language while at the same time refusing to biologize aggression, or IQ, or the ecological crisis? Would it not suffice to assume that language is a socially determined set of human activities superimposed upon the enormous but unspecific complexity of a primate brain?

The justification for treating human language as a biological phenomenon comes from modern linguistics. According to Chomsky and his followers, human language, irrespective of race and culture, is based on innate grammatical and syntactic structures common to all normal human beings. To a biologist, this can mean only that somehow the inner structure of language is genetically determined. That is, language and its intellectual correlates are the functional manifestation of a specific, genetically determined system of nervous connections in the cerebral cortex. The enormous growth of the human brain cortex in the astonishingly short time of a few hundred thousand years may have been a correlate of the development of language, just as the expansion of a lobe in the brain of electric fishes was bound to the dependence of these animals on the detection of electric fields.

Note that a biology of language as I envision it here will include a biology of thinking processes such as logical structures, *a priori* ideas, artistic creation, and even ethical principles. To a very large extent the actual contents of these areas must, of course, be of environmental origin, just as the actual language you and I, or a Chinese or a Bantu, speak is dictated not by genes but by upbringing. At the same time, a biology of language could be a truly humane science since it would address itself to qualities common to all men, not to differences between men. It may generate an applied science too, by discovering better ways to teach, to learn, and to make use of what we learn.

How to approach the biology of human language and thereby also the biology of the human mind is not yet easy to see. Behavior geneticists have barely started to analyze biologically the behavior of *Escherichia coli* or of the fruitfly. And in man we cannot isolate mutants or perform controlled crosses. At any rate, the genetic basis of human language is likely to involve not one or a few genes but thousands.

A start on the biology of language can be made by observing the derangements produced by accidents or disease or genetic mutation or chemical poisoning onto linguistic functions on the one hand and on the brain network on the other hand. Some work of this kind is being done by Alexander Luria in the Soviet Union and by Norman Geschwind and others in the United States. But new techniques and ideas will probably be needed.

It may seem unwise or grandiose to put forward as a legitimate goal for biologists a study with so little immediate prospect for rapid advance. My reason for doing so is that I believe the real relevance of science is to cultivate, as immediate or ultimate goals, a vision of the resolution of the great mysteries of nature. As we toil at our individual tasks, investigating the function of a gene or the structure of a membrane or the specificity of a synapse, we gain if we connect our work with some further and grander goal.

Several years ago Peter Medawar epitomized the pursuit of science as "The Art of the Soluble." Truly and correctly, this excludes from the purview of science the pursuit of mirages generated by wishful thinking. Yet when all self-delusion is excluded, there remain true problems, still insoluble but already visible as challenges to the scientists—like the Himalayas to a mountain climber. By facing them with courage and imagination, and with proper restraint, we remain faithful to the ideals of science. □